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EXPERIMENTAL INVESTIGATION OF S – TYPE LOAD CELL IN STEEL EN24 AND ALUMINIUM 7075

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ABSTRACT

S type load cell is used currently in Automobile industry, S type load cell is designed in CATIA V5 and strain analysis is analyzed by software ANSYS 14.5. S type load cell is designed first with the dimensions analyzed (Elastic strain sensitivity) finally the design was finalized. After finalizing of dimension the analyzing strain for Steel-EN24 and Aluminium-7075. Comparing the material's sensitivity and choosing the sensitive material for S-type load cell. Manufacture a model of load cell by 3D printing technology with the specified dimensions.

KEYWORDS: Automobile Industry, S-type, Strain, cell & Technology

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Original Article

INTRODUCTION

Load cells are used for measurement of forces in the wind tunnel, while testing, aerodynamics model, shown in Figure 1. A load cell is a sensor that converts a load or force acting on it into electronic signals. To the applied load the most commonly load cell is available with particularly based on the principle of change in resistance. A load cell is made using strain gauges.

Figure 1:1S-Type Load Cell Setup for Wind Tunnel Test

To find a load cell any kind of weighing machine or electric scales can be used commonly. A transducer which is used is highly accurate and which gives users with the required information. Owing to certain commercial factors other technology finds difficult to obtain.

Applications of this kind are mostly used in industrial scales, load-testing machines etc. For structural beam and support beam, these load cells are mostly used. In this research, the six-component wind tunnel balance is designed. [1] Platform is of balance type. Onto the set of six load cells, aerodynamic load which acts on a model in the wind tunnel test section is transferred. Using the balance load cells the relations between all load cells are

gauged. With dead weights, balance, calibration is done and the same results are shown.

For force measurement a transducer known as load cell used for creating an electric signal. Electrical connections are important for the system to behave satisfactorily. Different shapes like rectangular and elliptical gauge areas are used in this study. To identify the best shape which gives better accuracy is S type load cell was selected and are used to check the variation of the strain. Using Autodesk Inventor© the designs are modeled and the simulation study is carried out using ANSYS Workbench 15. The optimal positions for strain gauge mounting are obtained and the gauge area cross sections are analyzed. Foil type linear strain gauges used, for experimental study. Compression loading, load cells are tested on UTM. The multi-meter is used for measuring the output voltage. On a graph the experimental results are plotted output voltage (mV) vs. applied load (kg) and also the best linear fit is plotted. With EN24 material the experimental study is carried out to elliptical gauges and rectangular areas. The results are compared with each other.

For shape optimization of "S" type load cell ANSYS is used for stress analysis in 'S' type load cell used in this research is done by using finite element method. Without exceeding allowable stress, the stress analysis is carried out to minimize the weight of 'S' type load cell. To find out the optimum solution the intention of the work is to create the geometry of "S" type load cell. Design changes satisfying all the criteria till the procedure are repeated until. Experimental results are compared with FEM results.

A passive micro strain gauge with a mechanical amplifier has been designed, analyzed, and tested. Under an optical microscope, residual strain in films can be directly measured, the mechanical amplifier provides a high gain. With a mechanical amplifier beam theories have been used to analyze the strain gauge, and the results were verified by a finite-element analysis.

To evaluate sensitivities, coupling errors and nonlinearity error calibration tests were performed.

To determine the force-strain relation in a customized interbody implant an analytical model is used. By finite element modeling, strain gauges were mounted onto the implant after validation and connected to a telemetry transmitter. Measuring load on an intradiscal implant over the course of healing provides key information about the mechanics of this process. Loads may be used to indicate performance demands on the intervertebral disc and interbody implants for subsequent implant design.

In two companion papers, a new high precision six-axis load cell is presented. The first paper is focused on the presentation of the conceptual design, the modeling, embodiment design and load cell. The three components of both a force and a moment acting on the load cell can able to be measured itself. The six-axis load cell of the sensing structural element is basically a threespoke structure.

Types of Load Cell

They are available in different sizes, shapes and capacities. There are different types of load cells available.

1 S Type

S Type is shown in the figure, the digital output is provided at maximum deflection when load cell are used in compression or tension.

Figure 2: S-Type Load Cell

1S-TYPE LOAD CELL

As the name indicates it is a load cell which is of S shape shown in fig 3. This type load cell has two holes at the top and at the bottom of the surface from which tension or compression can be applied. In the middle of the load cell the strain gauges are fitted which measures the force applied and converts it into in an analog or digital form. This load cell has one major advantage: bending moment results shows same magnitude values in positive and negative stresses. The founded magnitude stress results acting on the wheatstone bridge its showing the tensile strain and compressive strain. When the bonded close together, thermal effects are minimize for the given strain values.

Figure 3: S-Type Load Cell

Specification

- High Performance
- Low Cost
- Excellent Sensitivity and Repeatability
- Suggested for both Tension and Compression

Advantages

- Rugged and Compact Construction
- No Moving Parts
- Can be Used for Static and Dynamic loading
- Highly Accurate
- Wide range of Measurement

Disadvantages

- Mounting is difficult

- Calibration is a tedious procedure

INTRODUCTION TO CATIA V5

CATIA is a computer aided three dimensional interactive applications. CATIA V5, V6 version modules are available in the market, mainly used to surface finish and 3d modelling applications. In the early stages CATIA used in the aerospace application later added the more application in all over industrial features. Compared to modelling software's like pro-E, solid works, Creo it is user friendly.

Model Diagram

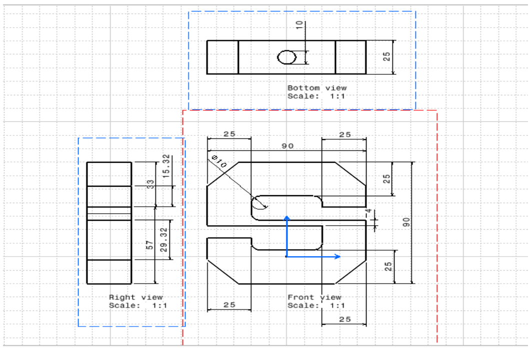

Figure 4: Model Diagram

Design of S type Load Cell

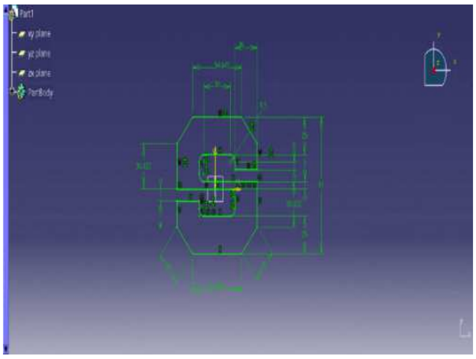

Figure 5: S Type Load Cell Constrained

Load Cell in Catia V5

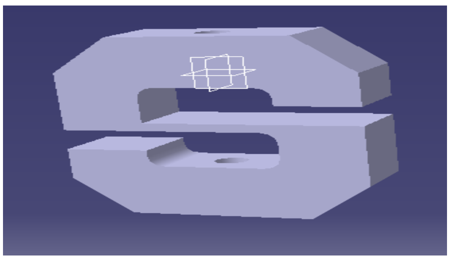

Figure 6: Load Cell

S-Type Load Cell Views

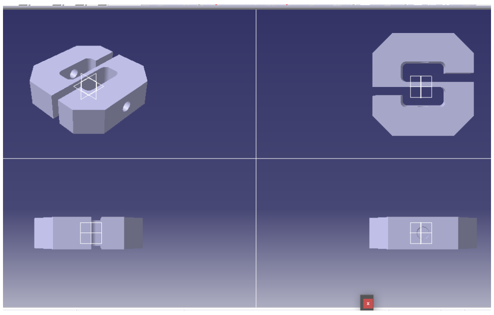

Figure 7: Various Views of Load Cell

S-Type Load Cell 3D Printing Model

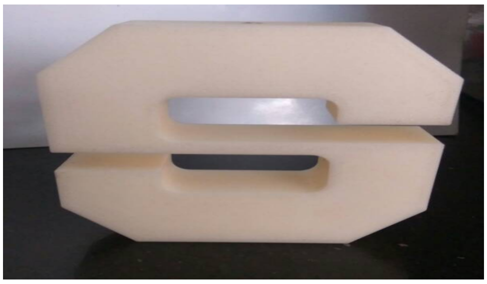

Figure 8: S-Type Load Cell 3D Printing Model

INTRODUCTION TO ANSYS

The ANSYS batch language has many features of the FORTRAN programming language. If statements and do loops can all be included in ANSYS batch files. In addition, ANSYS has several built-in functions for further manipulation of ANSYS results or geometry parameters.

There two primary ways to use ANSYS interactively through the graphical user interface and through the use of batch files and ANSYS commands. In this project, we have used the GUI. Interactive ANSYS has disadvantages such as it requires the user to save the model geometry, mesh, and results in a *.db file.

Generic Steps in ANSYS

Import Catia Part Model in ANSYS

Step 1

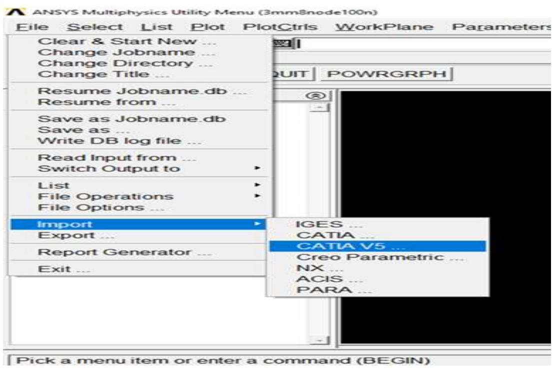

Figure 9: Importing

Step 2

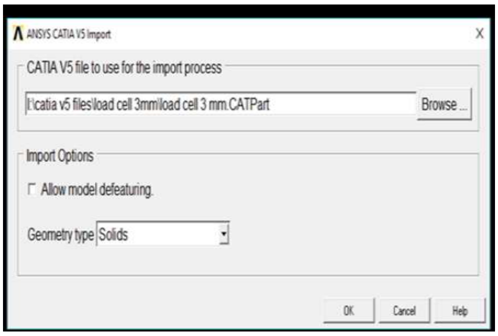

Figure 10: File Selection

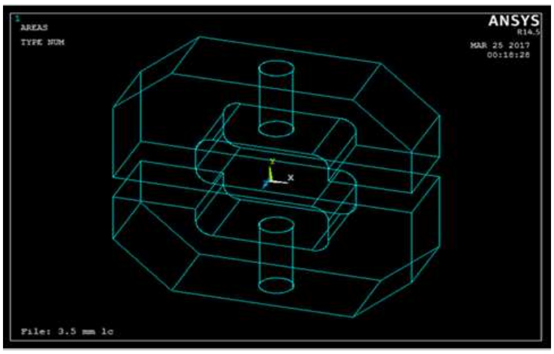

Figure 11: Wire Drawing View

Step 3

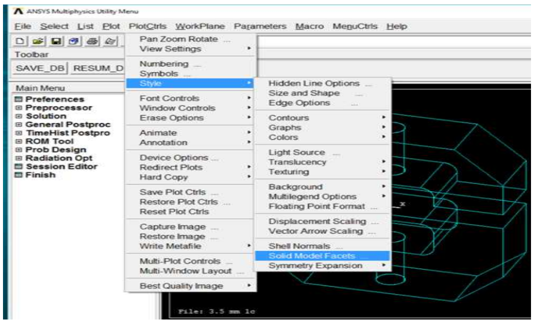

Figure 12: Plot ctrl Steps

Step 4

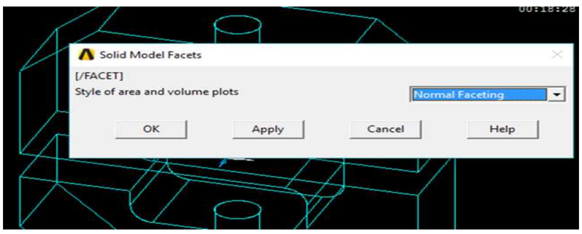

Figure 13: Select Faceting

Step 5

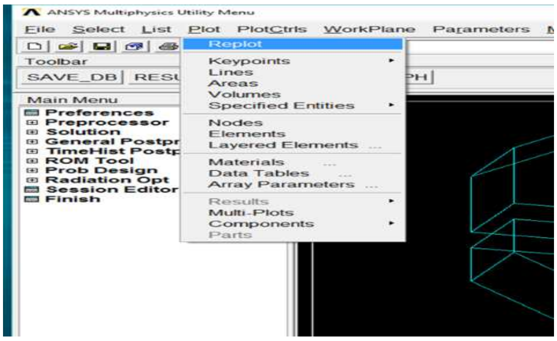

Figure 14: Repotting

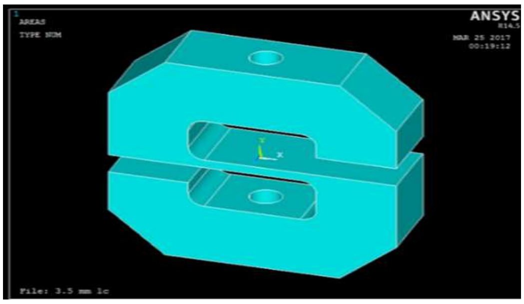

Figure 15: Solid View of S-Type Load Cell

Define Material Properties

Material Used

- S-Type Load cell are made from Steel EN-24 and
- Aluminium-7075.

Material Properties

Table 1: Properties

Properties	Steel-EN24	Aluminium-7075
Young's modulus	$2e^5 N/m^2$	$0.7e^5 N/m^2$
Poission ratio	0.3	0.3
Tensile Yield Strength	700 to 900 Mpa	503 Mpa

Selection of Element Type

Pre-processor > element type > Add/Edit/Delete > Add > solid > 10node187.

Generate Mesh

At this point ANSYS understands the makeup of the part. Now define how the Modelled system should be broken down into finite pieces. In a load cell design we did mesh to meshing model.

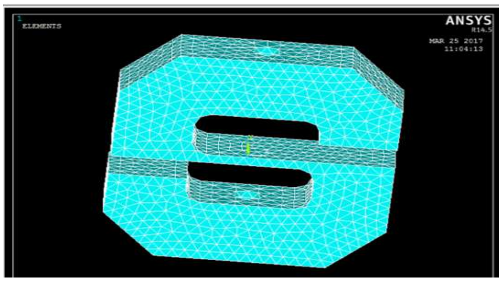

Figure 17: Meshing

Apply Load

Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions. In the wind tunnel forces, lift force 150N, drag force 100N and side force 75N.

The bottom side of the load cell is displaced in all DOF and the load can apply around the hole placed on top side of load cell by selecting key-points.

The applied load is divided into the number of key-points selected.

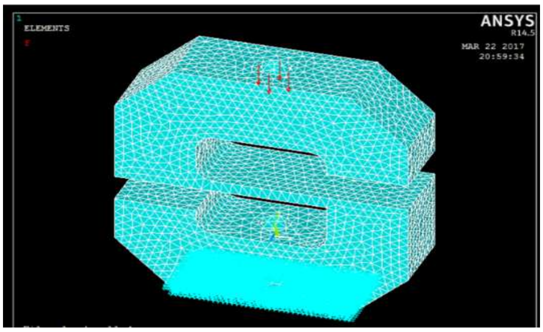

Figure 18: Apply Load on Key-Nodes

Elastic Strain Analysis

The linear static analysis was performed to determine the stress and strain results from the finite element model. The elastic strain distributes on X-component in the load cell.

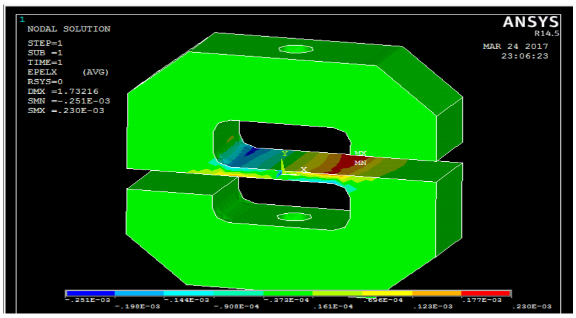

Figure 19: 150N Load Act on Steel

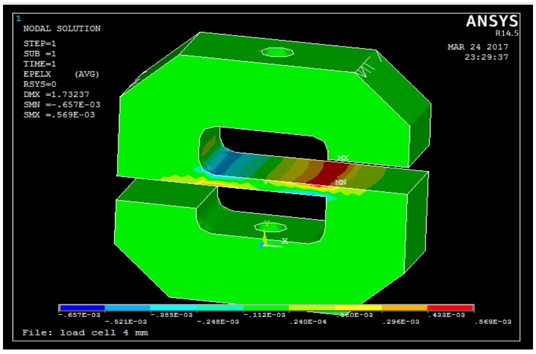

Figure 20: 150N Load Act on Aluminium

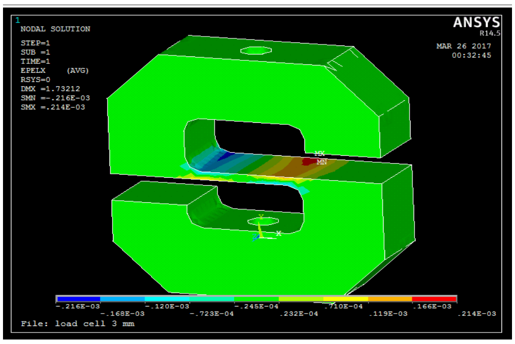

Figure 21: 100N Load Act on Steel

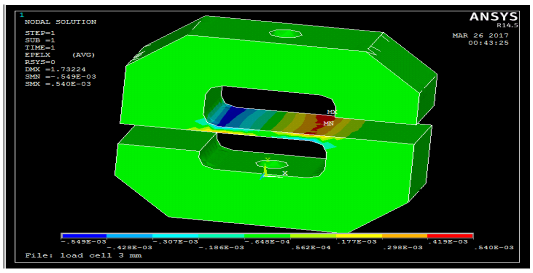

Figure 22: 100N Load Act on Aluminium

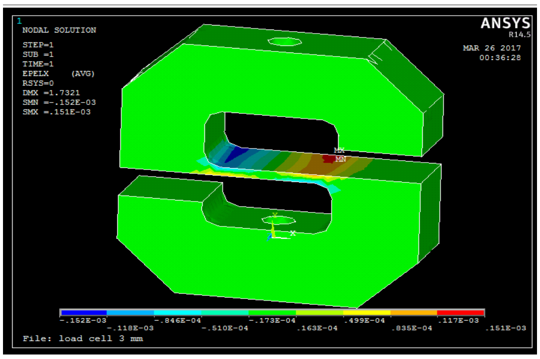

Figure 23: 75N Load Act on Steel

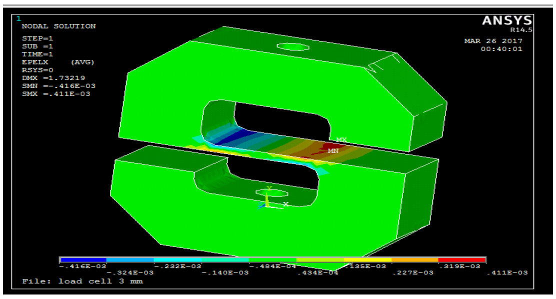

Figure 24: 75N Load Act on Aluminium

CALCULATION AND COMPARISON - SENSITIVITY CALCULATION FOR STEEL-EN24

Sensitivity Calculation for 150N Load on 4mm Thin Middle Plate of Load Cell

Elastic Strain in X-component

S_{min}=-0.2e^{-3}	S_{max}=0.2e^{-3}
S_{max} × e^{6} = 200μe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

200μe × 4 = 800μe
Sensitivity = 800μe/150N = 5.33 μe/N

Sensitivity Calculation for 100N Load on 4mm Thin Middle Plate of Load Cell

Elastic Strain in X-Component

S_{min}=-0.16e-3	S_{max}=0.12e-3
S_{max} × e6 = 120μe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

200μe × 4 = 800μe
Sensitivity = 480μe/100N = 4.8 μe/N

Sensitivity Calculation for 100N Load on 3mm Thin Middle Plate of Load Cell

Elastic Strain in X-Component

S_{min}=-0.21e-3	S_{max}=0.21e-3
S_{max} × e6 = 210μe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

210μe × 4 =840μe
Sensitivity = 840μe/100N = 8.4 μe/N

Sensitivity Calculation for 75N Load on 3mm Thin Middle Plate of Load Cell (Steel-EN24)

Elastic Strain in X-Component

S_{min}=-0.15e-3	S_{max}=0.16e-3
S_{max} × e6 = 160μe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

160µe × 4 =640µe
Sensitivity = 640µe/75N = 8.53 µe/N

Sensitivity Calculation for Aluminium-7075

Sensitivity Calculation for 150N Load on 4mm Thin Middle Plate of Load Cell

Elastic Strain in X-Component

S_{min}=-0.65e-3	S_{max}=0.56e-3
S_{max} × e6 = 560µe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

560µe × 4 = 2240µe
Sensitivity = 800µe/150N = 14.93 µe/N

Sensitivity Calculation for 100N Load on 3mm Thin Middle Plate of Load Cell (Aluminium-7075)

Elastic Strain in X-Component

S_{min}=-0.54e-3	S_{max}=0.54e-3
S_{max} × e6 = 540µe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

540µe × 4 = 2160µe
Sensitivity = 2160µe/100N = 21.6 µe/N

Sensitivity Calculation for 75N Load on 3mm Thin Middle Plate of Load Cell

Elastic Strain in X-Component

S_{min}=-0.41e-3	S_{max}=0.41e-3
S_{max} × e6 = 410µe/strain gauge	

Minimum Number of Strain Gauge Placed on Load Cell = 4

410µe × 4 = 1640µe
Sensitivity = 1640µe/75N = 21.86 µe/N

*(Above 5µe/N sensitivity is able to read on the strain measuring device)

Comparison of Steel-En24 and Aluminium-7075

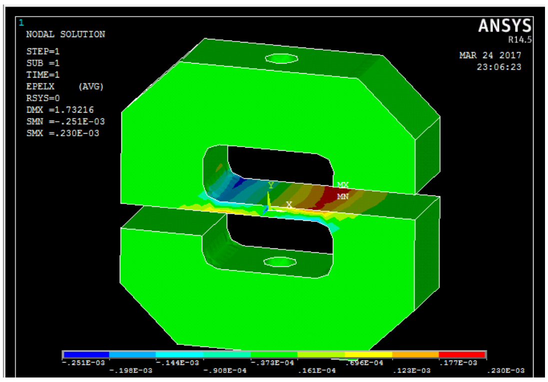

Figure 25: 150N Elastic Strain in Steel-EN 24

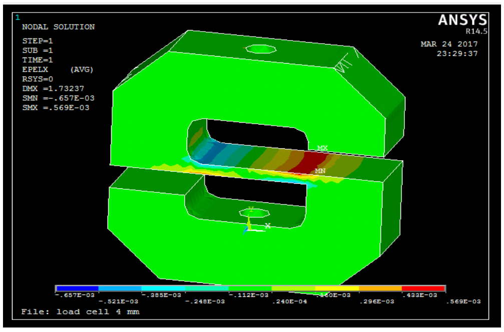

Figure 26: 150N Elastic Strain in Aluminium-7075

Elastic Strain for 100N Load in Load Cell

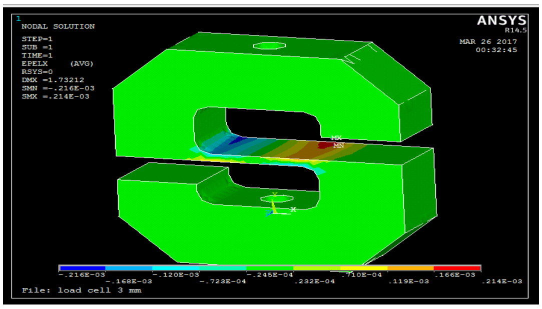

Figure27: 100N Elastic Strain in Steel EN24

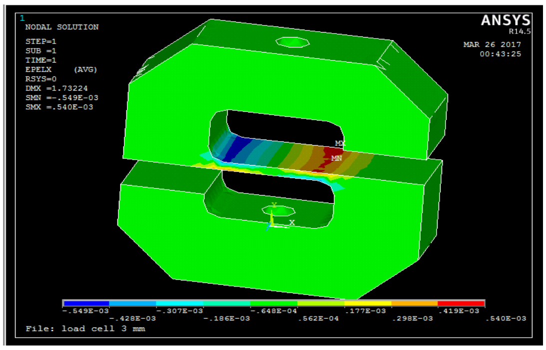

Figure 28: 100N Elastic Strain in Aluminium-7075

Elastic Strain for 75N Load in Load Cell

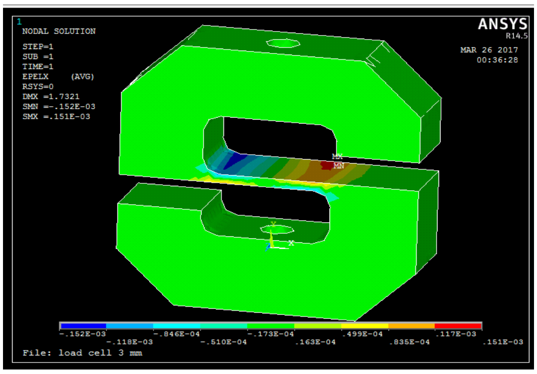

Figure 29: 75N Elastic Strain in Steel-EN24

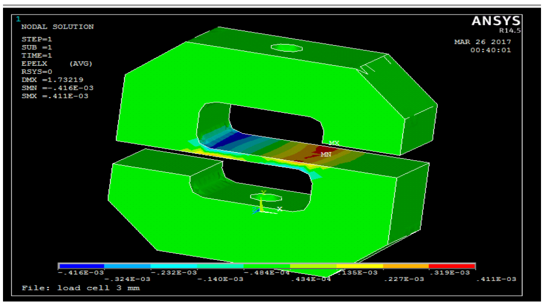

Figure 30: 75N Elastic Strain in Aluminium-7

Strain Sensitivity Comparison between Steel-EN24 and Aluminium7075

Table 2: Sensitivity Comparison

Force	Load (N)	Strain Sensitivity (με/N)	
		Steel-EN24	Aluminium-7075
LIFT	150	5.33	14.93
DRAG	100	8.4	21.6
SIDE	75	8.53	21.86

Bar Chart Comparison

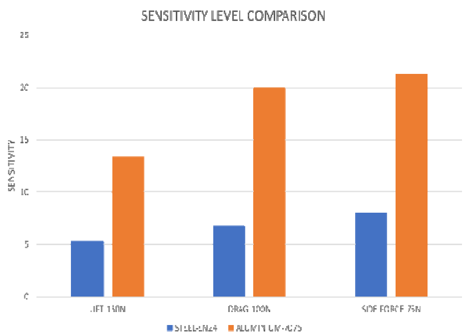

Figure 31: Sensitivity Level Comparison

CONCLUSIONS

This study shows that the strain sensitivity of the applied load on the load cell for getting accurate strain value and comparison of two materials for threecomponent balance measurement of low -speed wind tunnel. By observing the result of sensitivity between Steel-EN24 and Aluminium-7075. The Aluminium-7075 material is suitable for S-type load cell. Making a load cell model in 3D printing.

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